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Approved for use through 09/30/00. OMB 0651-0032

Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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**UTILITY PATENT APPLICATION TRANSMITTAL**  
(Only for new nonprovisional applications under 37 CFR 1.53(b))Attorney Docket No. 042390.P5698D Total Pages 24First Named Inventor or Application Identifier BhatiaExpress Mail Label No. EL627467075USjc930 U.S. PTO  
09/604143

10/05/00

**ADDRESS TO: Commissioner of Patents & Trademarks**  
**Box Patent Application**  
**Washington, D. C. 20231****APPLICATION ELEMENTS**

See MPEP chapter 600 concerning utility patent application contents.

1. X Fee Transmittal Form  
(Submit an original, and a duplicate for fee processing)
2. X Specification (Total Pages 24)  
(preferred arrangement set forth below)
  - Descriptive Title of the Invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claims
  - Abstract of the Disclosure
3. X Drawings(s) 9 (35 USC 113) (Total Sheets 5)
4. X Oath or Declaration (Total Pages 4)
  - a.      Newly Executed (Original)
  - b. XXX Copy from a Prior Application (37 CFR 1.63(d))  
(for Continuation/Divisional with Box 17 completed) (**Note Box 5 below**)
  - i.      DELETIONS OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. X Incorporation By Reference (useable if Box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

jc945 U.S. PTO  
10/05/00

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6. \_\_\_\_\_ Microfiche Computer Program (Appendix)

7. \_\_\_\_\_ Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)

- a. \_\_\_\_\_ Computer Readable Copy  
b. \_\_\_\_\_ Paper Copy (identical to computer copy)  
c. \_\_\_\_\_ Statement verifying identity of above copies

#### ACCOMPANYING APPLICATION PARTS

8. \_\_\_\_\_ Assignment Papers (cover sheet & documents(s))

9. \_\_\_\_\_ a. 37 CFR 3.73(b) Statement (where there is an assignee)

\_\_\_\_\_ b. Power of Attorney

10. \_\_\_\_\_ English Translation Document (if applicable)

11. \_\_\_\_\_ a. Information Disclosure Statement (IDS)/PTO-1449

\_\_\_\_\_ b. Copies of IDS Citations

12. XX Preliminary Amendment

13. XX Return Receipt Postcard (MPEP 503) (Should be specifically itemized)

14. \_\_\_\_\_ a. Small Entity Statement(s)

\_\_\_\_\_ b. Statement filed in prior application, Status still proper and desired

15. \_\_\_\_\_ Certified Copy of Priority Document(s) (if foreign priority is claimed)

16. \_\_\_\_\_ Other: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

17. If a **CONTINUING APPLICATION**, check appropriate box and supply the requisite information:

\_\_\_\_\_ Continuation XX Divisional \_\_\_\_\_ Continuation-in-part (CIP)

of prior application No: 09/028,203

18. **Correspondence Address**

X Customer Number or Bar Code Label 008791  
(Insert Customer No. or Attach Bar Code Label here)

or

X Correspondence Address Below

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12/01/97

- 2 -

PTO/SB/05 (12/97)

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**FEE TRANSMITTAL FOR FY 2001****TOTAL AMOUNT OF PAYMENT (\$)** 710.00**Complete if Known:****Application No.** Unknown**Filing Date** Herewith**First Named Inventor** Rakesh Bhatia**Group Art Unit** Not yet assigned**Examiner Name** Not yet assigned**Attorney Docket No.** 042390.P5698D**METHOD OF PAYMENT (check one)**

1. ☒ [XX] The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

**Deposit Account Number** 02-2666**Deposit Account Name** BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, LLP☐ [XX] Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

2. ☒ XX Payment Enclosed:

☒ XX Check☐ Money Order☐ Other**FEE CALCULATION****1. BASIC FILING FEE**

<u>Large Entity</u>		<u>Small Entity</u>		<u>Fee Description</u>	<u>Fee Paid</u>
<u>Fee Code</u>	<u>Fee (\$)</u>	<u>Fee Code</u>	<u>Fee (\$)</u>		
101	710	201	355	Utility application filing fee	<u>710.00</u>
106	320	206	160	Design application filing fee	<u>          </u>
107	490	207	245	Plant filing fee	<u>          </u>
108	710	208	355	Reissue filing fee	<u>          </u>
114	150	214	75	Provisional application filing fee	<u>          </u>
<b>SUBTOTAL (1)</b>					<b>\$ <u>710.00</u></b>

**2. EXTRA CLAIM FEES**

		<u>Extra Claims</u>	<u>Fee from below</u>	<u>Fee Paid</u>
<b>Total Claims</b>	<u>9</u>	- 20** = <u>0</u>	X <u>          </u>	= <u>00</u>
<b>Independent Claims</b>	<u>1</u>	- 3** = <u>0</u>	X <u>          </u>	= <u>00</u>
<b>Multiple Dependent</b>			<u>          </u>	= <u>          </u>

**\*\*Or number previously paid, if greater; For Reissues, see below.**

<u>Large Entity</u>		<u>Small Entity</u>		<u>Fee Description</u>	
<u>Fee Code</u>	<u>Fee (\$)</u>	<u>Fee Code</u>	<u>Fee (\$)</u>		
103	18	203	9	Claims in excess of 20	
102	80	202	40	Independent claims in excess of 3	
104	270	204	135	Multiple dependent claim, if not paid	
109	80	209	40	**Reissue independent claims over original patent	
110	18	210	9	**Reissue claims in excess of 20 and over original patent	
<b>SUBTOTAL (2)</b>					<b>\$ <u>710.00</u></b>

**FEE CALCULATION (continued)****3. ADDITIONAL FEES**

<u>Large Entity</u>		<u>Small Entity</u>		<u>Fee Description</u>	<u>Fee Paid</u>
<u>Fee Code</u>	<u>Fee (\$)</u>	<u>Fee Code</u>	<u>Fee (\$)</u>		
105	130	205	65	Surcharge - late filing fee or oath	_____
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	_____
139	130	139	130	Non-English specification	_____
147	2,520	147	2,520	For filing a request for reexamination	_____
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	_____
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	_____
115	110	215	55	Extension for response within first month	_____
116	390	216	195	Extension for response within second month	_____
117	890	217	445	Extension for response within third month	_____
118	1,390	218	695	Extension for response within fourth month	_____
128	1,890	228	945	Extension for response within fifth month	_____
119	310	219	155	Notice of Appeal	_____
120	310	220	155	Filing a brief in support of an appeal	_____
121	270	221	135	Request for oral hearing	_____
138	1,510	138	1,510	Petition to institute a public use proceeding	_____
140	110	240	55	Petition to revive unavoidably abandoned application	_____
141	1,240	241	620	Petition to revive unintentionally abandoned application	_____
142	1,240	242	620	Utility issue fee (or reissue)	_____
143	440	243	220	Design issue fee	_____
144	600	244	300	Plant issue fee	_____
122	130	122	130	Petitions to the Commissioner	_____
123	50	123	50	Petitions related to provisional applications	_____
126	240	126	240	Submission of Information Disclosure Stmt	_____
581	40	581	40	Recording each patent assignment per property (times number of properties)	_____
146	710	246	355	For filing a submission after final rejection (see 37 CFR 1.129(a))	_____
149	710	249	355	For each additional invention to be examined (see 37 CFR 1.129(b))	_____
179	710	279	355	Request for Continued Examination (RCE)	_____
169	900	169	900	Request for expedited examination of a design application	_____
Other fee (specify) _____					_____
Other fee (specify) _____					_____

**SUBTOTAL (3) \$710.00**

\*Reduced by Basic Filing Fee Paid

**SUBMITTED BY:**Typed or Printed Name: Jeffrey S. DraegerSignature:  Date: October 5, 2000Reg. Number: 41,000 Telephone Number: 408-720-8300

Docket No.: 42390.P5698D

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re the application of: )  
 )  
Bhatia )  
 )  
Serial No.: not yet assigned ) Examiner: Not yet assigned  
 )  
Filed: herewith ) Art Unit: Not yet assigned  
 )  
 )  
 )  
Divisional of )  
Serial No.: 09/028,203 )  
Filed: 2/23/98 )  
 )  
For: A HEAT EXCHANGER FOR A )  
PORTABLE COMPUTING DEVICE )  
UTILIZING ACTIVE AND PASSIVE )  
HEAT DISSIPATION MECHANISMS )  
 )  
\_\_\_\_\_ )

**PRELIMINARY AMENDMENT**

Commissioner for Patents  
and Trademarks  
Washington, D.C. 20231

Dear Sir:

Please enter the following preliminary amendment in conjunction with applicant's  
divisional application filed herewith.

IN THE CLAIMS

Please cancel without prejudice claims 1-6.

7. (Amended) [The heat exchanger of claim 1 wherein the at least one heat transfer mechanism comprises:] A heat exchanger comprising
- a first heat dissipation mechanism having a first heat dissipation capacity;
- a second heat dissipation mechanism having a second heat dissipation capacity;
- a variable thermal conductivity heat pipe having a first portion thermally coupled to [the] a heat generating component, a second portion thermally coupled to the first heat dissipation mechanism, and a third portion separated from the first portion and the second portion by [the] a limited conductivity portion and thermally coupled to the second heat dissipation mechanism.

8. (Amended) The heat exchanger of claim [1]7 wherein the [at least one heat transfer mechanism]variable thermal conductivity heat pipe has a first thermal path with a first thermal conductivity which couples the heat generating component to the first heat dissipation mechanism and has a second thermal path with a second thermal conductivity which couples the heat generating component to the second heat dissipation mechanism and wherein the first thermal conductivity is at least twice the second thermal conductivity and the first heat dissipation mechanism is an active heat dissipation mechanism.

9. (Amended) The heat exchanger of claim [8]7 wherein the heat generating component is a processor and wherein the second thermal conductivity is approximately four times the first thermal conductivity.

10. (Amended) The heat exchanger of claim [8]7 wherein the first heat dissipation mechanism is an active heat dissipation mechanism that is enabled depending on at least the temperature of the heat generating component.

11. (Amended) The heat exchanger of claim [1]7 wherein the first heat dissipation mechanism is a fan based heat exchanger and wherein the second heat dissipation mechanism is a thermally conductive plate beneath and substantially parallel to a keyboard.

Please cancel without prejudice claims 13-16.

Please cancel without prejudice claims 22-26.

27. (New) An apparatus comprising:

at least one electronic component;

a heat pipe having a limited conductivity portion, the heat pipe having a first portion

thermally coupled to the at least one electronic component;

a fan based heat exchanger thermally coupled to a second portion of the heat pipe;

a metallic plate coupled to a third portion of the heat pipe and separated from the first

portion that is connected to the at least one electronic component by the limited

conductivity portion of the heat pipe.

28. (New) The apparatus of claim 27 wherein the metallic plate comprises a plate

substantially beneath a keyboard.

29. (New) The apparatus of claim 27 wherein said limited thermal conductivity

portion of said heat pipe comprises a narrowed portion of said heat pipe.

30. (New) The apparatus of claim 28 wherein the metallic plate comprises a portion of

a thermally enhanced keyboard.

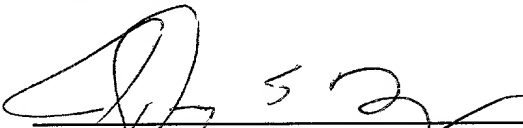
#### **REMARKS**

Applicant submits that all claims now pending are in condition for allowance at least by

way of dependency on an allowable independent claim. Such action is earnestly solicited at the earliest possible date. If there is a deficiency in fees, please charge our Deposit Acct. No. 02-2666.

Respectfully submitted,

Date: October 5, 2000

  
Jeffrey S. Draeger, Reg. No. 41,000

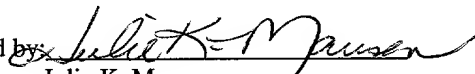
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Julie K. Mause

Date Signed: October 5, 2000

UNITED STATES UTILITY PATENT APPLICATION

FOR

A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND  
PASSIVE HEAT DISSIPATION MECHANISMS

Inventors:

Rakesh Bhatia

42390.P5698

Prepared by:

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12400 Wilshire Boulevard, Seventh Floor  
Los Angeles, California 90025-1026  
(408) 720-8598

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2/23/98  
(Date signed)

A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND  
PASSIVE HEAT DISSIPATION MECHANISMS

5 Background of the Invention

1. Field of the Invention

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10 The present invention pertains to the field of heat dissipation in  
an electronic device. More particularly, the present invention pertains  
to the use of multiple heat dissipation mechanisms to cool one or more  
electronic components.

2. Description of Related Art

15 Faster and more powerful computer components allow the design and  
construction of higher performance portable computing devices such as  
laptop or notebook computers. Unfortunately, the use of such faster and  
more powerful computer components often results in increased heat  
generation by such computing devices.

20 Additionally, as some computer components shrink and/or increasing  
computer component integration shrinks overall computer size, electronic  
components may be arranged in a more compact form. Such increasing  
component density coupled with decreasing overall computing device size  
inherently decreases space available for convective airflow and  
25 accordingly raises heat dissipation concerns. Thus, improved heat  
dissipation technology is often needed to maintain operating temperatures

within an acceptable range in smaller and/or more powerful portable computing devices.

Maintaining operating temperatures of computer system components below certain levels is important to ensure performance, reliability, and safety. Most integrated circuits have specified maximum operating temperatures, above which the manufacturer does not recommend operation. Additionally, transistors on an integrated circuit tend to slow down as operating temperature increases. Thus, a computer system that operates its integrated circuits close to or beyond recommended timings may fail as temperature increases.

Additionally, integrated circuits may be physically damaged if temperatures elevate beyond those recommended. Such physical damage obviously can impact system reliability. Finally, the computer system casing should be kept at a temperature which is safe for human contact. This may necessitate spreading of heat throughout a computer system base or efficiently expelling heat to avoid hot spots near certain components such as a processor.

One prior art technique for cooling an electronic component in a portable computing device is to conduct heat from the electronic component to a plate beneath the device's keyboard using a heat pipe affixed by a heat conductive block to the electronic component. As increasing amounts of heat are generated by the electronic component, this technique may cause the plate beneath the keyboard and hence the keyboard to reach temperatures which are too hot for safe or comfortable use. Thus, such passive heat dissipation techniques may prove insufficient in some applications.

Active techniques have also been employed to cool electronic components in portable computing devices. One example of a prior art active heat dissipation technique is to use a fan based heat exchanger. In one prior art approach, a thermal connection exists between an electronic component and a fan based heat exchanger having heat dissipation fins. The thermal connection includes a thermal block connecting the electronic component to the heat pipe and, in some cases, the heat pipe being connected to the heat dissipation fins through an outer casing of the heat exchanger.

Each additional element in the thermal path from the heat generating component to the heat dissipation mechanism may result in decreased thermal conductivity between the electronic component and the heat dissipation fins. As a result, a thermal path from the electronic component to the fins having numerous elements may be somewhat inefficient. Moreover, if active heat dissipation is the only mechanism provided for heat dissipation, the active dissipation is likely necessary when the portable computing device is relying on battery power. Consequently, the active thermal solution may disadvantageously drain the battery.

Thus, the prior art does not adequately combine multiple heat dissipation mechanisms to cool portable computing devices. The prior art also does not provide a combination active and passive thermal solution which enables the active dissipation mechanism at a varying power level based on temperature and/or power source. Furthermore, the prior art does not demonstrate the use of multiple heat dissipation mechanisms where a passive heat dissipation mechanism is coupled to a heat generating component by a thermal path having a limited thermal

[illegible]

## Summary

5           A heat exchanger is disclosed. The heat exchanger includes a first  
heat dissipation mechanism having a first heat dissipation capacity and a  
second heat dissipation having a second heat dissipation capacity. At  
least one heat transfer mechanism thermally couples the first heat  
dissipation mechanism and the second heat dissipation mechanism to a heat  
10 generating component. The heat transfer mechanism has a limited  
conductivity portion in the thermal path to either the first or the  
second heat dissipation mechanism.

15

20

## Brief Description of the Figures

The present invention is illustrated by way of example and not  
5 limitation in the figures of the accompanying drawings.

**Figure 1** illustrates one embodiment of a portable computing device.

**Figure 2a** illustrates a front cross sectional view of one  
10 embodiment of the attachment of a heat dissipation mechanism to a heat generating component.

**Figure 2b** illustrates a side cross sectional view of the embodiment of Figure 2a taken along section line 2B-2B.

**Figure 3A** illustrates a front cross sectional view of the  
15 attachment of a heat dissipation mechanism to a heat generating component according to another embodiment.

**Figure 3b** illustrates a side cross sectional view of the embodiment of Figure 3a taken along section line 3B-3B.

**Figure 4** illustrates one embodiment of the use of a variable  
20 conductivity heat pipe.

**Figure 5** illustrates one embodiment of a method for cooling a heat generating component.

## Detailed Description

The following description provides a heat exchanger utilizing  
5 active and passive mechanisms. In the following description, numerous  
specific details such as particular component sizes and types as well as  
particular physical locations for components and heat dissipation  
mechanisms are set forth in order to provide a more thorough  
understanding of the present invention. It will be appreciated,  
10 however, by one skilled in the art that the invention may be practiced  
without such specific details.

The present invention advantageously utilizes multiple heat  
dissipation devices to cool a portable computing device. In one  
embodiment, active and passive heat dissipation devices are used, such  
15 that the active heat dissipation device may be enabled at a power level  
which may vary depending on whether the heat generating component is  
operating at a certain power or temperature level or in a particular  
mode, such as when external power is applied. Furthermore, one  
embodiment utilizes a limited thermal conductivity portion in a thermal  
20 path and may therefore provide separate thermal paths which have thermal  
conductivities proportional to the heat dissipation capacity of the  
different heat dissipation devices connected thereto. Such varying  
thermal conductance may allow a keyboard to maintain an acceptable  
temperature by limiting the amount of heat transferred to a heat  
25 dissipation plate beneath the keyboard.

Figure 1 illustrates a portable computing device 100. The  
portable computing device may be a notebook or laptop computer or

another type of computing device such as a personal organizer, personal digital assistant, or any similar type of computing device. Additionally, the heat exchanger may be utilized in non-portable computing devices.

5 A base portion 105 of the portable computing device 100 includes a thermally enhanced keyboard (TEK) 102. In one embodiment, the TEK includes a keypad 108 and a keyboard plate 110 which may be used to dissipate heat through the keypad 108. In another embodiment, the keyboard plate 110 may be one or more flat heat pipes which are  
10 integrally formed or otherwise affixed beneath the keypad 108. An integral keyboard and heat pipe is described in US patent application no. 08/854,185 entitled "Integral Keyboard and Heat Pipe," filed May 9, 1997, which is hereby incorporated by reference.

The base portion 105 includes a motherboard 115 which is connected  
15 to a processor module 130 by connectors 117a and 117b. In the illustrated embodiment, two heat generating components are mounted on the processor module 130. In one embodiment, these heat generating components are a processor 140 and a bridge 145. In other embodiments, other integrated circuits or the module 130 itself may be cooled.

20 In the illustrated embodiment, a heat pipe 120 has a first portion 120a which is thermally coupled to the bridge 145 and the processor 140. This first portion 120a of heat pipe 120 may be flattened as it contacts the processor 140 and the bridge 145. The heat pipe 120 may then return to a cylindrical shape as it moves away from the module 130.  
25 Alternatively, the entire heat pipe 120 may be flat or may be formed into any shape which can be thermally coupled to heat generating components such as the processor 140 and the bridge 145.

A second portion 120b of the heat pipe 120 extends away from the module 130 toward a rear corner of the base portion 105. At the rear corner of the base portion 105 is an active heat dissipation device, in this embodiment a fan based heat exchanger 160. The fan based heat exchanger 160 forms a duct which channels air driven by a fan 170. Heat dissipation fins 165 are directly welded to the heat pipe 120 to minimize the number of interfaces through which the heat must pass. Additionally, the outer housing of the heat exchanger 160 may be a heat conductive material and may also be welded to the second portion 120b of heat pipe 120.

In alternative embodiments, the fins and duct may be otherwise arranged. It is generally preferred to directly attach the fins to the heat pipe or extrude the fins and the heat pipe as one unified body. For example, a flat heat pipe may be extruded to have fins extending perpendicular to flat portions of the heat pipe. With the fins extending from the heat pipe (especially if fins extend axially in all directions from the heat pipe), the duct which channels air may be formed by plastic or other materials.

The passive portion of the heat exchanger is formed by the keyboard plate 110. The keyboard plate 110 is thermally coupled to the processor 140 and the bridge 145 via a heat path which includes a limited conductivity portion (a heat transfer block 150 in this embodiment) to limit the amount of heat transferred to the passive element (the keyboard plate 110). As illustrated, the heat transfer block 150 may have grooves on one surface thereby limiting the amount of surface contact and hence the thermal conductivity along the thermal path to the passive heat dissipation device.

Further details of one embodiment of the connection between the heat pipe 120 and the heat generating components are shown in Figure 2a. The processor 140 shown in Figure 1 includes a processor die 205 as well as a number of contacts (not shown) for making electrical connections with the processor module 130. In this embodiment, the first portion 120a of the heat pipe 120 is directly connected to the processor 205. A thermal grease or other similar material such as a compressive and thermally conductive elastomer may be used to enhance the thermal transfer characteristics of the direct connection between the processor die 205 and the heat pipe 120. In contrast, prior art techniques typically employ a thermal transfer block or a slug between a processor die and a heat pipe.

According to the embodiment illustrated in Figure 2a, the thermally conductive heat transfer block 150 is fastened on top of the processor die 205 and the heat pipe 120. The heat transfer block 150 is fastened to the processor module 130 by four fasteners, one on each corner. From the illustrated perspective, only two fasteners may be seen, fasteners 210a and 210b. The heat transfer block 150 in this embodiment includes grooves 220 which reduce the thermal conductivity of the thermal path from the processor die 205 and the bridge 145 to the keyboard plate 110. Indeed, only the ridge portions such as the ridge 230 contact the keyboard plate. A particular thermal conductivity may be achieved by adjusting the groove/ridge arrangement.

A decreased thermal conductivity (higher thermal resistance or  $\theta$ ) is intentionally produced in order to limit the heat transferred to the keyboard plate. If too much heat is transferred to the keyboard plate 110, the keyboard may become dangerously hot or at least may

exceed a desired maximum temperature. Thus, the thermal conductivity of this path may be set by adjusting the thermal conductivity of the limited conductivity portion (i.e., in this embodiment the grooved block) of the path.

5 The thermal conductivity selected for the thermal path from the processor die 205 to the keyboard plate 110 and the thermal conductivity of the thermal path from the processor die 205 to the fan based heat exchanger 160 are proportional to the heat dissipation capacity of the keyboard plate 110 and the heat dissipation capacity of the fan based  
10 heat exchanger 160. In other words, the thermal conductivities may be selected such that their ratio equals or is similar to the ratio of the heat dissipation capacities.

The heat dissipation capacity for the keyboard plate 110 is defined as the amount of heat the keyboard plate 110 can dissipate while  
15 remaining in the desired operating temperature range. The heat dissipation of the fan based heat exchanger 160 may vary with the power level (e.g., off, minimum, maximum, etc.) the fan 170. Thus, the ratio may be matched for a particular power level of the fan as needed to assure that the keyboard maintains an acceptable temperature. Since a  
20 variety of fan speeds may be used, the fact that thermal paths are proportional to heat dissipation capacities does not imply that a strict mathematical equality of ratios must exist. Rather, the relative heat dissipation capacities are reflected in the respective thermal paths by the same general relationship (e.g., greater than, less than,  
25 approximately twice, etc.).

In one embodiment, the processor die 205 is capable of generating up to approximately twenty watts. Of this power, approximately four

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watts may be safely dissipated using the keyboard plate 110. The remaining heat may be dissipated via the active heat dissipation mechanism. Thus, in this embodiment, the thermal path to the active heat dissipation mechanism (e.g., the fan based heat exchanger 160) has approximately four times the thermal conductivity of the thermal path to the keyboard plate 110. In other embodiments, this ratio may vary substantially. Not only does the ratio depend on the heat dissipation capacity of both the active and passive mechanisms, but it also may depend on the total amount of heat generated by the heat generating devices and whether the devices can operate in different power consumption modes.

A side view of the arrangement of Figure 2a as taken through section line 2B-2B of Figure 2a is shown in Figure 2b. Figure 2b illustrates that the first portion 120a of the heat pipe 120 may be flattened to contact the processor die 205 with a larger surface area than might be possible with a cylindrical heat pipe. Indeed, in some embodiments, the entire heat pipe 120 may be flat or rectangular. Figure 2b also illustrates how the heat transfer block conforms to the shape of the portion of the heat pipe 120 which is directly attached to the processor die 205. Additionally, Figure 2b illustrates one of the rear fasteners, fastener 210c.

Figures 3a and 3b illustrate one alternative embodiment of the heat transfer block 150. Figure 3b illustrates a side cross section view of the embodiment of Figure 3a taken through section lines 3B-3B. As illustrated in these figures, the limited conductivity portion of the thermal path away from the heat generating components may be formed using a hollow heat transfer block 305 which has a cavity 310 filled

with a material having a lower thermal conductivity than the outer surface of the heat transfer block 305. In one embodiment, the heat transfer block 305 is aluminum and the cavity is filled with air. The exact materials used are not crucial, and varying conductivities may be achieved by varying either the materials or the proportion of the highly conductive material to that which is not.

Figure 4 illustrates one alternative embodiment which utilizes a variable thermal conductivity heat pipe 400 with two portions 405 and 415 to provide the two different thermal paths to the active and passive heat dissipation mechanisms. In this embodiment, a throttling portion 410 of the heat pipe 400 forms the limited conductivity portion which allows a smaller amount of heat to be transferred the passive heat dissipation mechanism, the keyboard plate 440.

The throttling portion 410 may be formed during manufacture of the heat pipe 400 or may be mechanically produced by pressure or bending of the heat pipe 400. The throttling portion 410 could also be formed by using a throttle valve which internally narrows the heat pipe and thereby limits heat flow. Alternatively, the heat pipe 400 may be pinched such that the first portion 405 and the second portion 415 form separate evaporator and condenser portions. One further alternative is for the first portion 405 to be a heat pipe and the second portion to include a gas reservoir separated from the heat pipe portion by a vapor-gas interface. The vapor-gas interface allows heat to be transferred between the two portions but keeps the vapor from the heat pipe portion separate from a gas (e.g., an inert gas) in the gas reservoir portion.

Thus the limited conductivity portion may include a throttling portion and another high thermal conductivity portion or may include an

entire portion having lower thermal conductivity. In any case, the limited conductivity portion may be used to limit the flow of heat to the keyboard plate 440 to apportion heat from the processor die 205 to the active heat dissipation mechanism and the keyboard plate 440 such  
5 the heat keyboard remains at an acceptable temperature.

Additionally, an optional heat transfer block 430 may be used to thermally couple the second portion 415 of the heat pipe 400 to the keyboard plate 440. The heat transfer block 430 may not be necessary if the heat pipe 400 is bent or otherwise arranged such that a direct  
10 connection to the keyboard plate may be made. On the other hand, the heat transfer block 430 may also be used to limit the heat flow to the keyboard plate 440. The heat transfer block 430 is not required because the variable thermal conductivity heat pipe 400 may alone limit the conductivity of the path to the keyboard plate 440.

15 Figure 5 illustrates one embodiment of a method of utilizing active and passive heat dissipation components. As shown in block 505, a first thermal path for transferring heat to a passive heat dissipation mechanism is provided. This first thermal path has a thermal resistance of  $\theta_1$ . A second thermal path to an active heat dissipation mechanism is  
20 provided as shown in block 510. The first thermal path has a substantially greater thermal resistance than the thermal resistance of the second thermal path( $\theta_2$ ). For example,  $\theta_1$  may be at least twice  $\theta_2$ .

As shown in block 515, the system senses power and/or thermal conditions to determine if active cooling is needed. In a portable  
25 computing device, the processor may include a temperature sensor, and other temperature sensors may be included on circuit boards or other computer system components such as CD ROM drives. Additionally, it may

be sensed whether external (e.g., alternating current) power is being supplied.

Depending on the various temperature measurements and whether external or battery power is being supplied, the active cooling mechanism may be enabled as shown in block 520. In fact, an active cooling mechanism such as a fan may be capable of operating at a number of power levels depending on these conditions. For example, the temperature which first causes a fan to be enabled may be higher if the system is operating on battery power.

As shown in block 525, whether or not the active heat dissipation mechanism is enabled, the passive heat dissipation mechanism may be used. In conjunction with the variable cooling available from the active heat dissipation mechanism, this combination can provide an intelligent system which provides multiple levels of heat dissipation and limits battery consumption.

Thus, the present invention provides a heat exchanger utilizing active and passive mechanisms. While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art upon studying this disclosure.

What is claimed is:

1. A heat exchanger comprising:

a first heat dissipation mechanism having a first heat  
dissipation capacity;

a second heat dissipation mechanism having a second heat  
dissipation capacity;

at least one heat transfer mechanism thermally coupling the  
first heat dissipation mechanism and the second heat  
dissipation mechanism to a heat generating component, the at  
least one heat transfer mechanism having a limited  
conductivity portion in a thermal path to one of the first  
and second heat dissipation mechanisms.

2. The heat exchanger of claim 1 wherein the at least one heat  
transfer mechanism has a first thermal path and a second thermal  
path which have respectively a first and a second thermal  
conductance proportional to the first and the second heat  
dissipation capacity.

3. The heat exchanger of claim 1 wherein the at least one heat  
transfer mechanism comprises:

a heat pipe thermally coupled to the heat generating component;  
and

a heat transfer block which forms the limited conductivity  
portion, the heat transfer block being thermally coupled to  
the heat generating component.

4. The heat exchanger of claim 3 wherein the heat transfer block is a grooved heat transfer block having a plurality of grooves on a surface which is a part of the second thermal path.

5

5. The heat exchanger of claim 3 wherein the heat transfer block is a hollow heat transfer block having an outer surface and an internal cavity, the internal cavity containing a material having a lower thermal conductivity than the outer surface of the heat transfer block.

10

6. The heat exchanger of claim 1 wherein the heat generating component is an integrated circuit having an integrated circuit die, and wherein the at least one heat transfer mechanism includes a heat pipe having a first portion directly attached to the integrated circuit die, and further wherein the heat pipe has a second portion which is a part of the second heat dissipation mechanism and to which a plurality of heat dissipation fins are directly welded.

15

7. The heat exchanger of claim 1 wherein the at least one heat transfer mechanism comprises:

20

a variable thermal conductivity heat pipe having a first portion thermally coupled to the heat generating component, a second portion thermally coupled to the first heat dissipation mechanism, and a third portion separated from the first portion and the second portion by the limited conductivity

25

portion and thermally coupled to the second heat dissipation mechanism.

8. The heat exchanger of claim 1 wherein the at least one heat transfer mechanism has a first thermal path with a first thermal conductivity which couples the heat generating component to the first heat dissipation mechanism and has a second thermal path with a second thermal conductivity which couples the heat generating component to the second heat dissipation mechanism and wherein the first thermal conductivity is at least twice the second thermal conductivity and the first heat dissipation mechanism is an active heat dissipation mechanism.

9. The heat exchanger of claim 8 wherein the heat generating component is a processor and wherein the second thermal conductivity is approximately four times the first thermal conductivity.

10. The heat exchanger of claim 8 wherein the active heat dissipation mechanism is enabled depending on at least the temperature of the heat generating component.

11. The heat exchanger of claim 1 wherein the first heat dissipation mechanism is a fan based heat exchanger and wherein the second heat dissipation mechanism is a thermally conductive plate beneath and substantially parallel to a keyboard.

12. The heat exchanger of claim 11 wherein the second heat dissipation capacity is determined in part by a maximum acceptable operating temperature for the keyboard.

5 13. A system comprising:

an electronic component;

a heat pipe thermally coupled to the electronic component;

a fan based heat exchanger thermally coupled to the heat pipe;

a heat transfer block thermally coupled to the electronic

10 component; and

a thermally enhanced keyboard thermally coupled to the heat transfer block.

14. The system of claim 13 wherein the electronic component is a

15 processor having a processor die and a plurality of contacts, and wherein the heat pipe is directly connected to the processor die.

15. The system of claim 13 wherein the thermally enhanced keyboard comprises:

20 a keyboard; and

a heat dissipation plate affixed beneath and substantially parallel to a substantial portion of the keyboard.

16. The system of claim 13 wherein the thermally enhanced keyboard comprises:

25 a keyboard; and

at least one flat heat pipe affixed beneath and substantially  
parallel to a substantial portion of the keyboard.

17. A system comprising:

- 5           an electronic component;
- a variable thermal conductivity heat pipe having a first portion  
          and a second portion separated by a throttling portion, the  
          electronic component being thermally coupled to the first  
          portion; and
- 10          a first heat dissipation mechanism thermally coupled to the  
          first portion of the variable thermal conductivity heat  
          pipe; and
- a second heat dissipation mechanism thermally coupled to the  
          second portion of the variable thermal conductivity heat  
15          pipe.

18. The system of claim 17 wherein the first heat dissipation mechanism  
is a fan based heat exchanger including a fan and a plurality of  
fins which are directly welded to the heat pipe.

20

19. The system of claim 18 wherein the plurality of fins are directly  
welded to the heat pipe.

20. The system of claim 18 wherein the plurality of fins are integrally  
25       formed with the heat pipe.

21. The system of claim 18 wherein the second heat dissipation mechanism is a heat dissipation plate affixed beneath and substantially parallel to a keyboard.

5 22. A method of cooling an electronic component comprising:  
sensing conditions during operation of the electronic component  
to determine whether active cooling is needed;  
enabling an active heat exchanger if active cooling is needed;  
and  
10 dissipating heat through a passive heat dissipation plate  
regardless of whether external power is being supplied.

23. The method of claim 22 wherein the sensing comprises sensing a temperature of the electronic component.

15 24. The method of claim 23 wherein the sensing further comprises sensing whether external power is being provided.

25. The method of claim 24 wherein the step of enabling comprises:  
20 enabling a fan at a power level dependent on the temperature of the electronic component and whether external power is being supplied.

26. The method of claim 22, further comprising:  
25 transferring heat via a first thermal path having a first thermal conductivity from the electronic component to an active heat dissipation mechanism;



## Abstract

A heat exchanger. The heat exchanger includes a first heat dissipation mechanism having a first heat dissipation capacity and a second heat dissipation having a second heat dissipation capacity. At least one heat transfer mechanism thermally couples the first heat dissipation mechanism and the second heat dissipation mechanism to a heat generating component. The heat transfer mechanism has a limited conductivity portion in the thermal path to either the first or the second heat dissipation mechanism.

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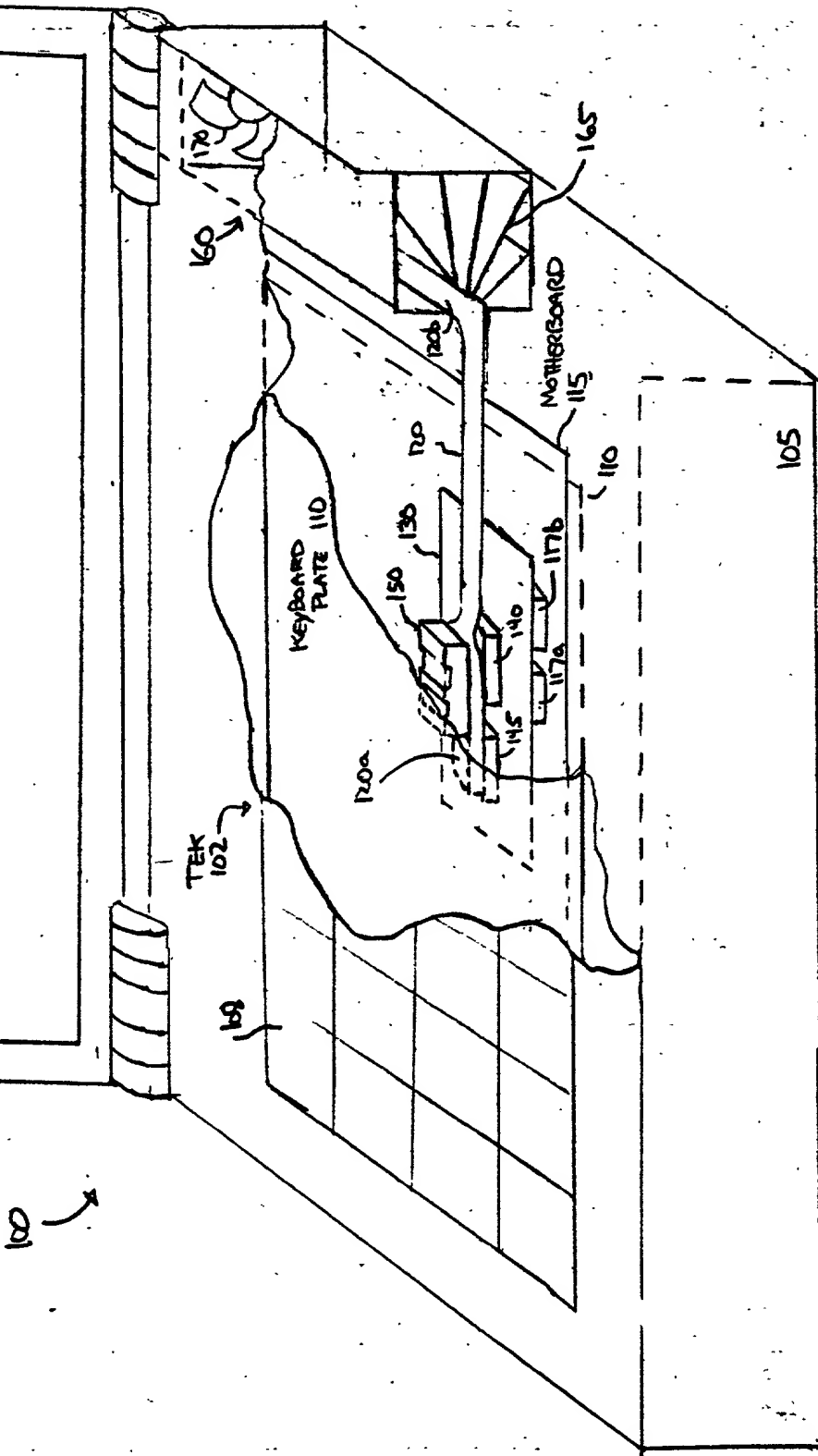


FIGURE 1

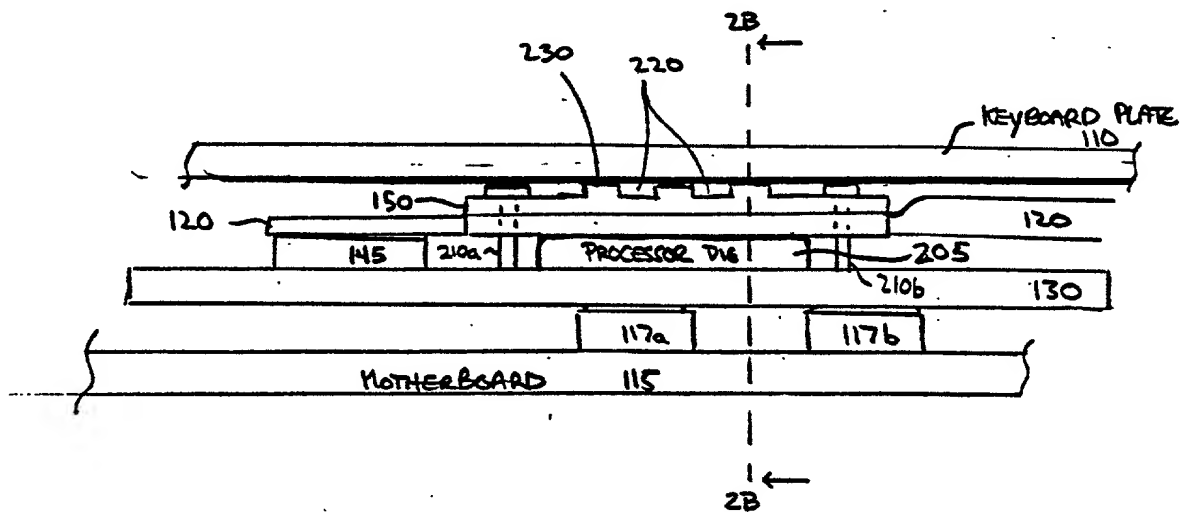


FIGURE 2A

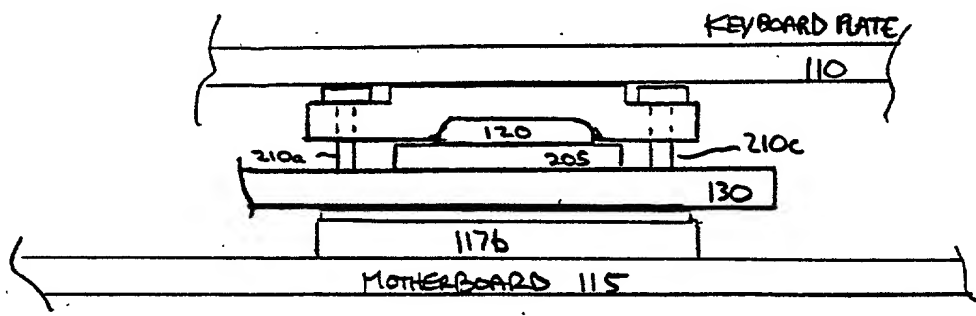


FIGURE 2B

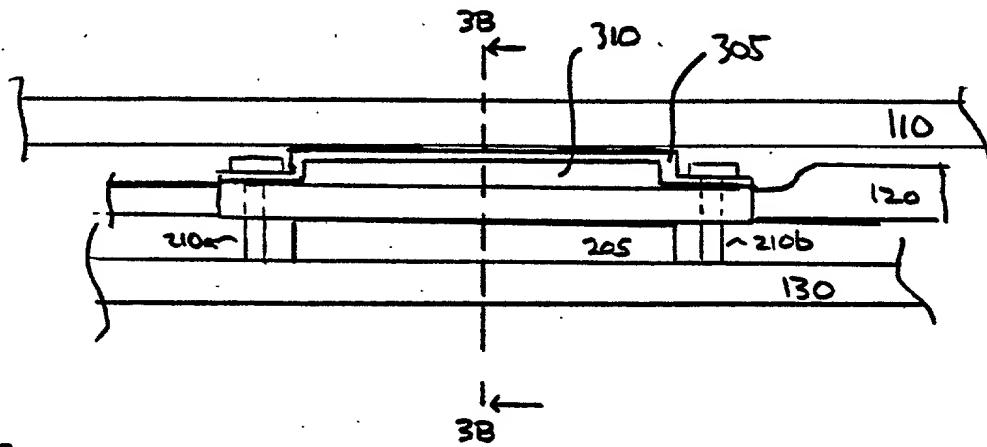


FIGURE 3A

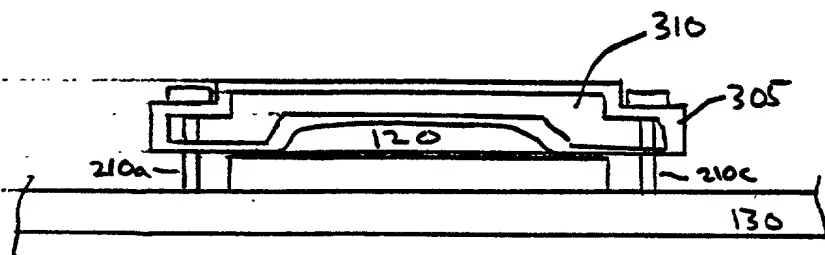
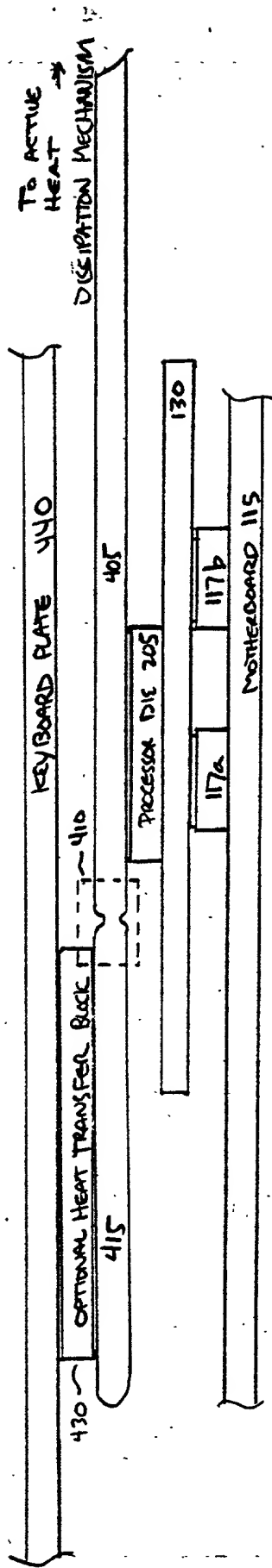


FIGURE 3B

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Page 4



22-141 50 SHEETS  
22-142 100 SHEETS  
22-144 200 SHEETS



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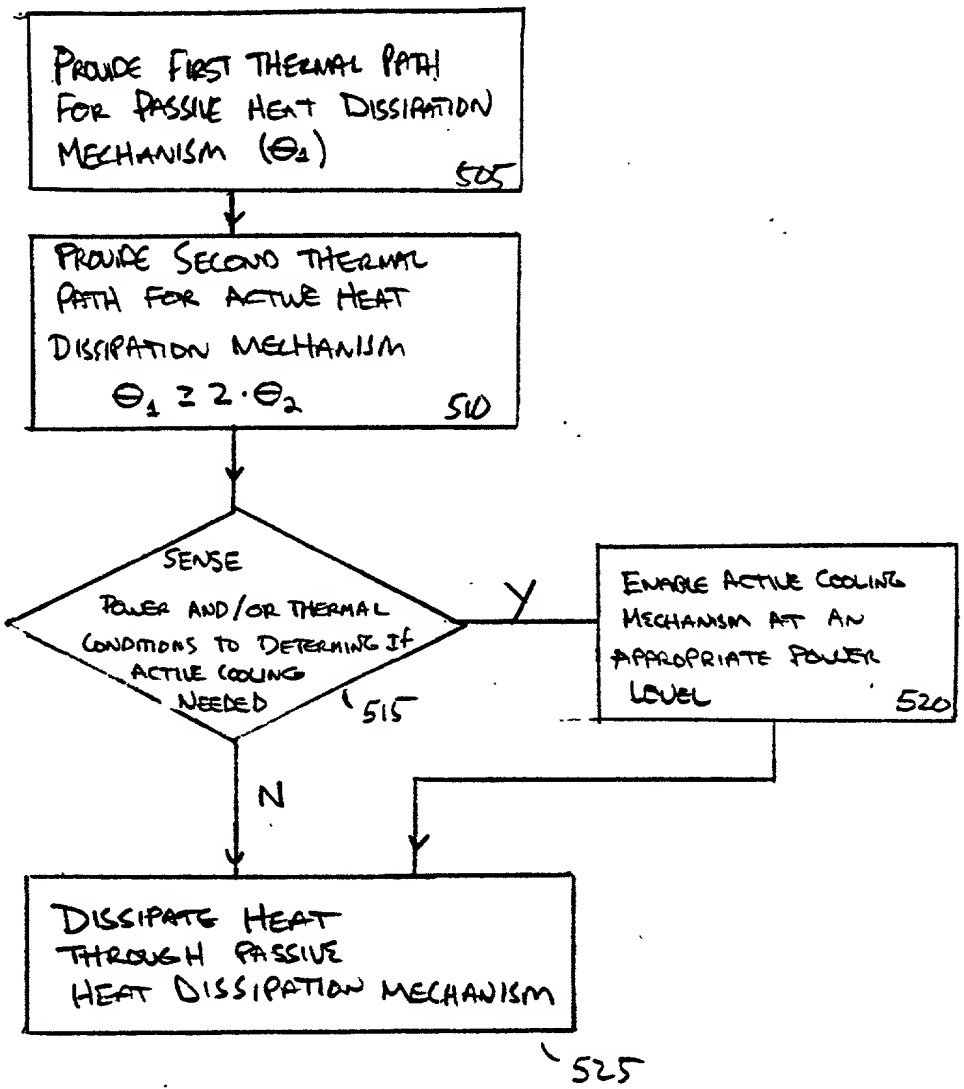


FIGURE 5

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Attorney's Docket No.: 42390.P5698

PATENT

**DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION**  
**(FOR INTEL CORPORATION PATENT APPLICATIONS)**

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

# A HEAT EXCHANGER FOR A PORTABLE COMPUTING DEVICE UTILIZING ACTIVE AND PASSIVE HEAT DISSIPATION MECHANISMS

the specification of which

[illegible]

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority  
Claimed

<u>(Number)</u>	<u>(Country)</u>	<u>(Day/Month/Year Filed)</u>	<u>Yes</u>	<u>No</u>
<u>(Number)</u>	<u>(Country)</u>	<u>(Day/Month/Year Filed)</u>	<u>Yes</u>	<u>No</u>
<u>(Number)</u>	<u>(Country)</u>	<u>(Day/Month/Year Filed)</u>	<u>Yes</u>	<u>No</u>

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

<u>(Application Number)</u>	<u>Filing Date</u>
<u>(Application Number)</u>	<u>Filing Date</u>

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

<u>(Application Number)</u>	<u>Filing Date</u>	<u>(Status -- patented, pending, abandoned)</u>
<u>(Application Number)</u>	<u>Filing Date</u>	<u>(Status -- patented, pending, abandoned)</u>

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Send correspondence to Michael J. Mallie, BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025 and direct telephone calls to Michael J. Mallie, (408) 720-8598.  
(Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
(City, State) (Country)

Post Office Address \_\_\_\_\_  
\_\_\_\_\_

Full Name of Third/Joint Inventor \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
(City, State) (Country)

Post Office Address \_\_\_\_\_  
\_\_\_\_\_

Full Name of Fourth/Joint Inventor \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
(City, State) (Country)

Post Office Address \_\_\_\_\_  
\_\_\_\_\_

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